UM10848

SSL5231DB1242 230 V/4 W non-isolated buck-boost candle-form dimmable LED driver dual demo board

Rev. 1.2 — 25 March 2015 **User manual**

Document information

Info	Content
Keywords	SSL5231DB1242, SSL5231T, non-isolated buck-boost topology, LED driver controller, external MOSFET switch, dimmable candle-form applications, SO8 package
Abstract	This user manual describes the performance, technical data, and the connection of the SSL5231DB1242 dual demo board. The demo board uses non-isolated buck-boost topology. This SSL5231DB1242 dual demo board is designed for dimmable candle-form applications. It operates at 230 V (AC) with an output voltage of approximately 90 V.

Revision history

Rev	Date	Description
v.1.2	20150325	updated issue
v.1.1	20150119	updated issue
v.1	20141024	first issue

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1. Introduction

WARNING

Lethal voltage and fire ignition hazard

The non-insulated high voltages that are present when operating this product, constitute a risk of electric shock, personal injury, death and/or ignition of fire.

This product is intended for evaluation purposes only. It shall be operated in a designated test area by personnel qualified according to local requirements and labor laws to work with non-insulated mains voltages and high-voltage circuits. This product shall never be operated unattended.

This user manual describes the operation of the SSL5231DB1242 dual demo board. The demo board features the MOSFET driver controller SSL5231T in a 230 V/4 W non-isolated buck-boost dimmable LED driver application.

The SSL5231DB1242 single demo board is designed for driving LED loads with 90 V nominal voltage and 4 W input power.

The PCB dimensions are compatible with candle-form applications.

The SSL5231DB1242 demo board provides a simple and highly efficient solution for Solid-State Lighting (SSL) applications.

1.1 Features

- Candle-form applications
- Supports most available leading-edge and trailing-edge dimmers
- Deep dimming level
- Flicker-free dimming
- Open/short LED string protection
- OverCurrent Protection (OCP)
- OverTemperature Protection (OTP)
- PF > 0.86
- Efficiency > 75 % at 230 V (AC) input
- Compliant with IEC61000-3-2 harmonic standard
- Compliant with EN55015 conducted EMI

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2. Safety warning

The demo board input is connected to the 230 V (AC) mains supply. Avoid touching the board while it is connected to the mains voltage and when it is in operation. An isolated housing is obligatory when used in uncontrolled, non-laboratory environments. Galvanic isolation from the mains phase using a fixed or variable transformer is always recommended. Figure 1 shows the symbols on how to recognize these devices.

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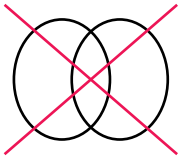
a. Isolated



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b. Not isolated

Fig 1. Isolation symbols

3. Specifications

Table 1 lists the specification of the SSL5231DB1242 demo board.

Table 1. SSL5231DB1242 specifications

Symbol	Parameter	Value
V_{mains}	AC mains supply voltage	230 V (AC); ±10 %
P_{in}	input power	4 W
V_{LED}	output voltage	90 V
I_{LED}	output current	≈37 mA
$I_{LED(ripple)}$	output current ripple	≈ 25 % (100 Hz)
$\Delta I_{LED}/\Delta V_{mains}$	line regulation	±3 % at V_{mains} = 207 V to 253 V
$\Delta I_{LED}/\Delta V_{LED}$	load regulation	±5 % at V_{LED}; −15 % to +7.7 %
η	efficiency	75 %; at 230 V (AC)/50 Hz
PF	power factor	> 0.86 at 230 V (AC)/50 Hz
T_{oper}	operating temperature	−40 °C to +105 °C
-	board dimensions	60 mm × 40 mm
-	conducted electromagnetic Interference (EMI)	EN55015
-	IEC61000-3-2	class D (for P_{in} < 25 W limit)
-	dimmer compatibility (stable light output above on/off point)	80 % dimmer compatibility for ≥ 2 lamps/dimmer

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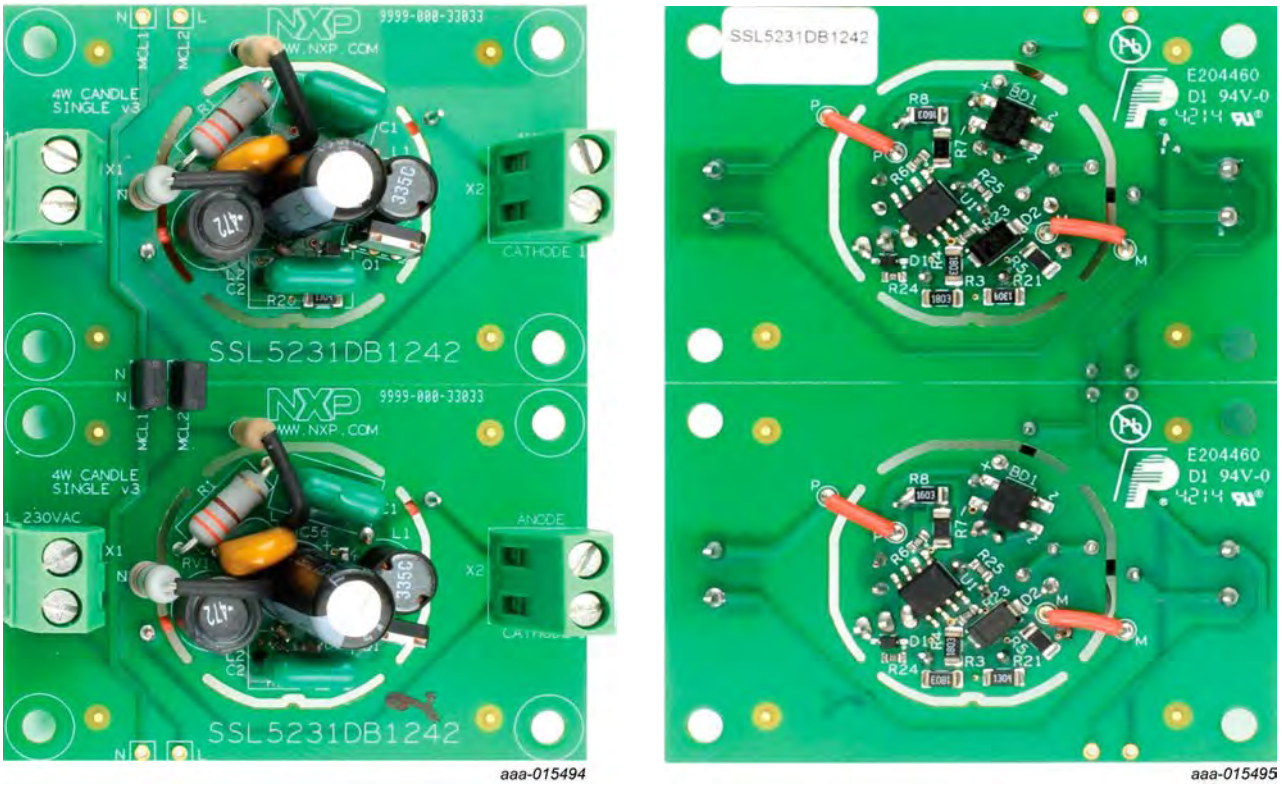
4. Board photographs

Figure 2 shows the top view and bottom view of the SSL5231DB1242 demo board. The board has been designed as a dual board. For dimmer tests, it is assumed that at least two lamps of 4 W are connected to one dimmer. However, the board can also be tested separately by removing the blue jumpers which can be seen in Figure 2 (a). At the left connector of the board (Figure 2 (a)), the AC mains (230 V) must be added. At the right connector, the LED load (90 V) must be connected. The inner part of the board can be taken out. It has a diameter of 28 mm which fits in a candle lamp.



a. Top view

b. Bottom view

Fig 2. SSL5231DB1242 dual demo board photographs

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5. Functional description

5.1 Input filtering

Capacitors C1 and C2 and inductor L1 (see Figure 10) filter the switching current from the buck-boost converter to the mains AC. Capacitors C1 and C2 also provide a low-impedance path for the converter output switching current.

The input series resistance of 660 Ω and capacitor C1 provide adequate protection against transient surge voltages.

5.2 Efficiency improvement for universal mains

The supply current for the SSL5231DB1242 demo board is supplied by resistors R3 and R4. The IC draws an additional start-up current ($I_{CC(startup)}$) just before VCC reaches the start-up voltage level ($V_{startup}$). The supply current in operation is therefore lower than during start-up conditions, preventing lamp flicker when the mains voltage is increased or decreased slowly. This mechanism also increases the dimming performance.

Figure 3 shows the basic behavior.

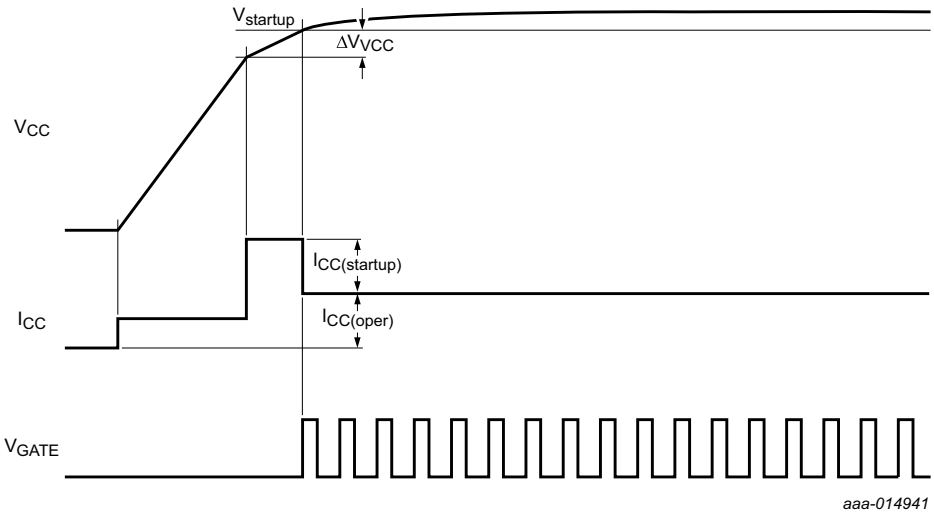

Fig 3. Start-up current waveform

5.3 Output open and output short protection

The driver board is protected when the LED load is accidentally left open. When the LED load is accidentally left open, the output voltage increases. When the OverVoltage Protection (OVP) level is reached on the DEMOVP pin, the OVP protection is triggered. OVP is a non-latched protection. It recovers when the LED string is reconnected. Resistors R6, R7, and R8 determine the OVP level. An output capacitor C56 voltage rating higher than the DC level which occurs when the LED load is accidentally left open must be ensured.

The measured OVP level is about 99 V.

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Remark: Do not reconnect the LED string directly after an OVP condition because it can permanently damage the LEDs. Switch off the mains and wait until the output capacitor is discharged.

When the LED driver output of the board is shorted, the maximum ISNS voltage limits the primary converter current. The converter frequency drops to its absolute minimum. This mode is very safe. The input power is very limited.

6. Performance

During performance tests V_{mains} = 230 V (AC) with a ±20 % margin, T_{amb} = 25 °C, I_{LED} = 37.4 mA typical, and V_{LED} = 90 V unless otherwise specified.

6.1 Efficiency

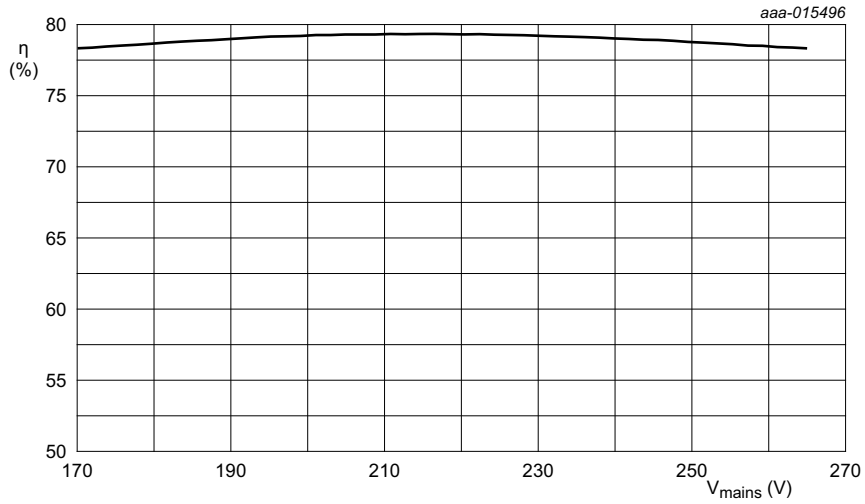

Fig 4. Efficiency as a function of V_{mains}

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6.2 Power factor

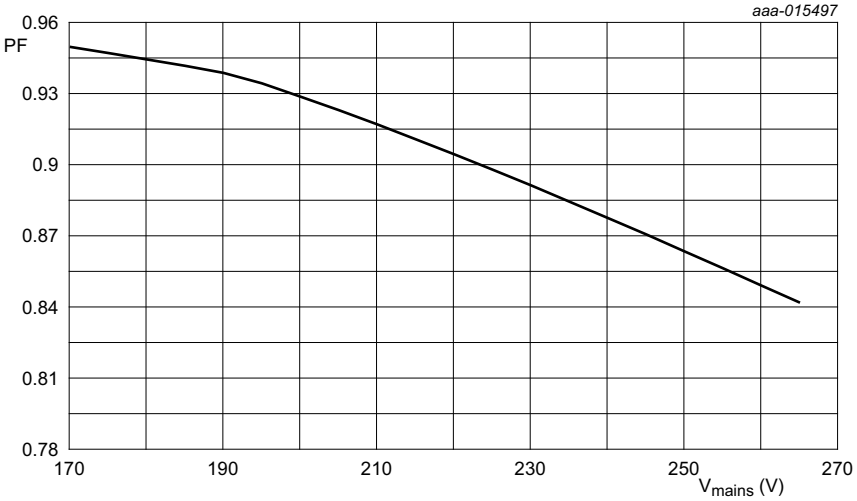

Fig 5. Power factor as a function of V_{mains}

6.3 Line regulation

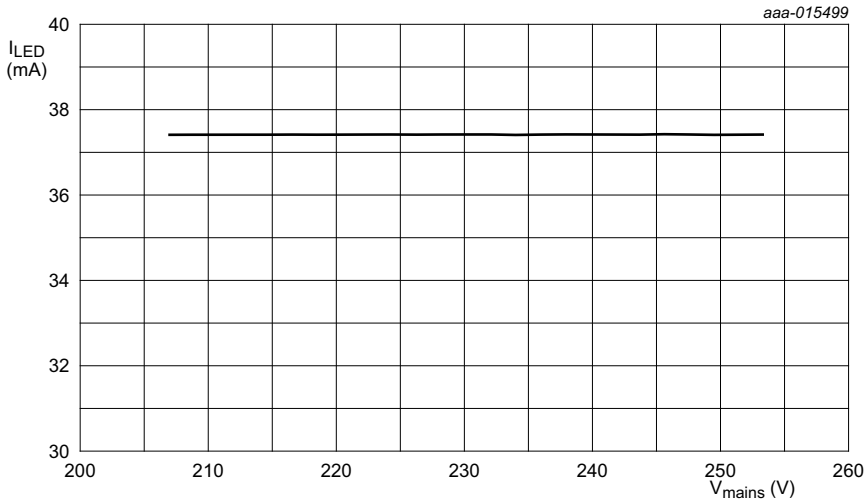

Fig 6. Line regulation

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6.4 Load regulation

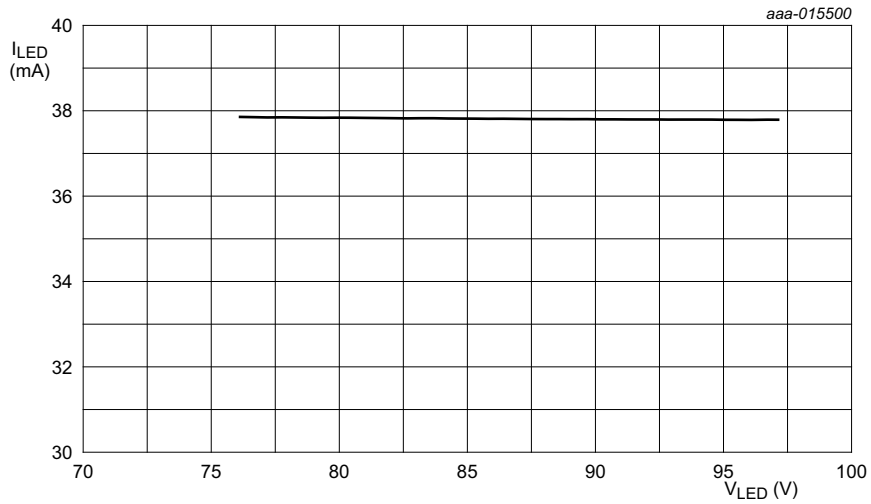

Fig 7. Load regulation

6.5 Output ripple

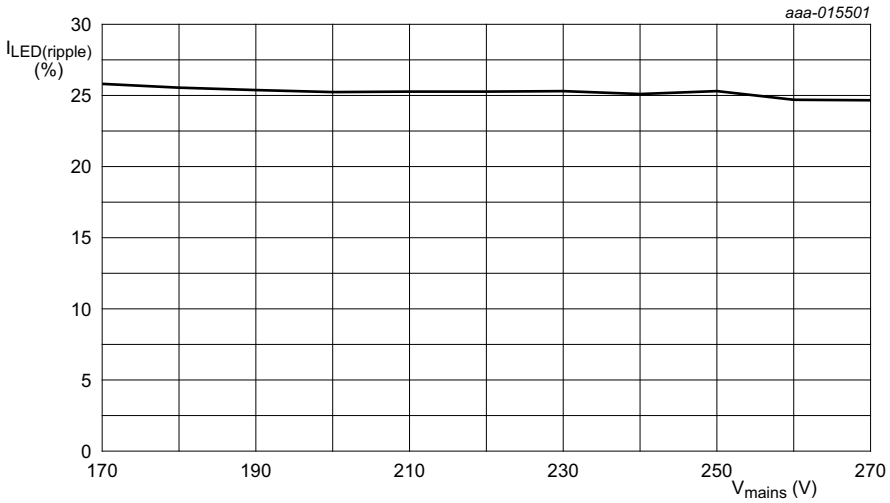

Fig 8. Output ripple as a function of V_{mains}

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6.6 ElectroMagnetic Interference (EMI)

Figure 9 shows the conducted EMI result of the SSL5231DB1242 demo board.

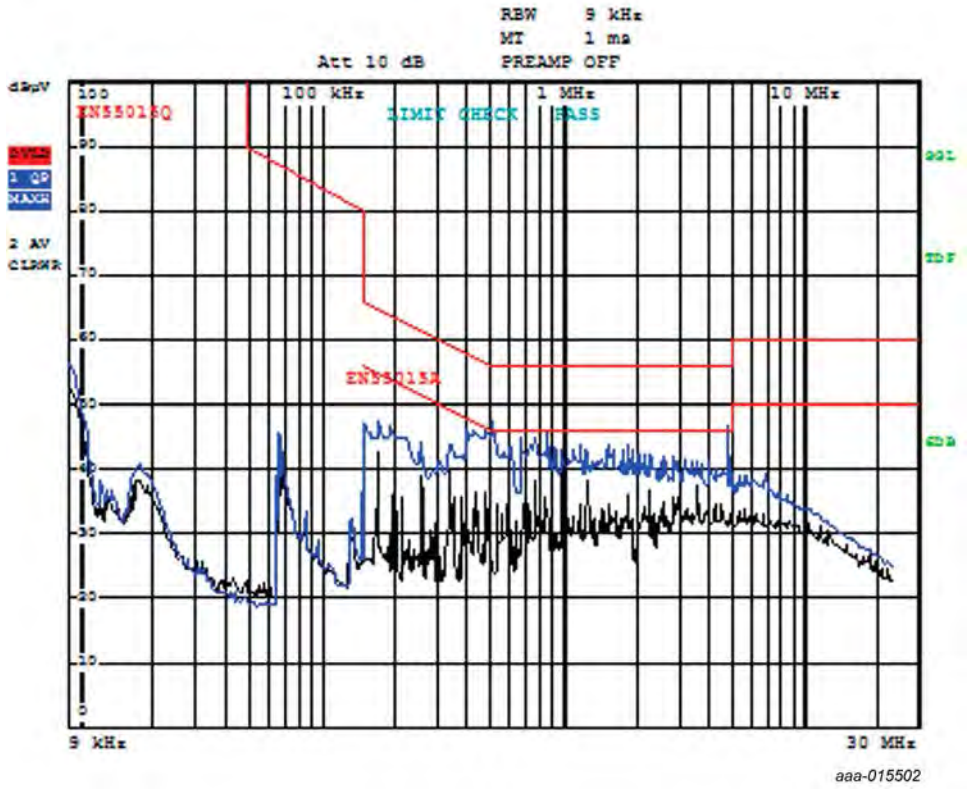

Fig 9. Conducted EMI

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7. Schematic

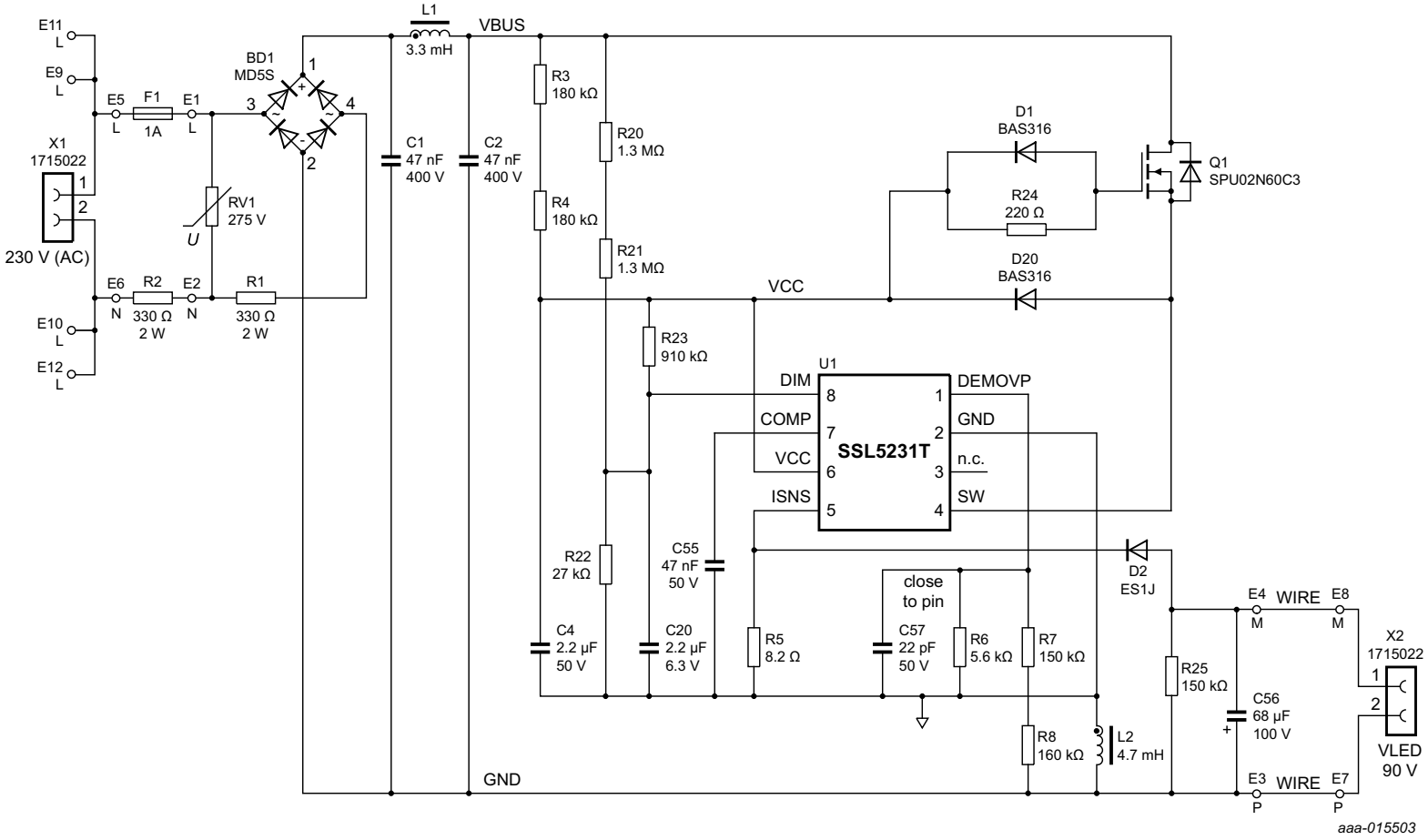

Fig 10. SSL5231DB1242 demo board schematic diagram

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8. Bill Of Materials (BOM)

Table 2. SSL5231DB1242 bill of materials

Reference	Description and values	Part number	Manufacturer
BD1	bridge rectifier; 1000 V; 500 mA	MD5S	Rectron
C1; C2	capacitor; 47 nF; 5 %; 400 V; PET; THT	CL21-400V-0.047µF/K	AIDI
C4	capacitor; 2.2 µF; 10 %; 50 V; X7R; 0805	C2012X7R1H225K125AC	TDK
C20	capacitor; 2.2 µF; 10 %; 6.3 V; X7R; 0603	C1608X7R0J225K080AB	TDK
C55	capacitor; 47 nF; 10 %; 50 V; X7R; 0603	-	-
C56	capacitor; 68 µF; 20 %; 100 V; ALU; 8 mm × 20 mm	100ZLJ68M8X20	Rubycon
C57	capacitor; 22 pF; 10 %; 50 V; X7R; 0603	-	-
D1; D20	diode; 100 V; 250 mA	BAS316	NXP Semiconductors
D2	diode; 600 V; 1 A	ES1J	Fairchild
F1	fuse; slow blow; 250 V (AC); 1 A	MCPMP 1A 250V	Multicomp
L1	inductor; 3.3 mH; 100 mA	22R335C	Murata
L2	inductor; 4.7 mH; 10 %; 0.11 A	744731472	Würth Elektronik
Q1	MOSFET-N; 650 V; 1.8 A	SPU02N60C3	Infineon
R1; R2	resistor; 330 Ω; 5 %; 2 W; MFP2	MFP2-330RJI	Welwyn Components
R3; R4	resistor; 180 kΩ; 1 %; 250 mW; 1206	-	-
R5	resistor; 8.2 Ω; 1 %; 63 mW; 0603	-	-
R6	resistor; 5.6 kΩ; 1 %; 63 mW; 0603	-	-
R7	resistor; 150 kΩ; 1 %; 250 mW; 1206	-	-
R8	resistor; 160 kΩ; 1 %; 250 mW; 1206	-	-
R20; R21	resistor; 1.3 MΩ; 1 %; 250 mW; 1206	-	-
R22	resistor; 27 kΩ; 1 %; 63 mW; 0603	-	-
R23	resistor; 910 kΩ; 1 %; 63 mW; 0603	-	-
R24	resistor; 220 Ω; 1 %; 63 mW; 0603	-	-
R25	resistor; 150 kΩ; 1 %; 63 mW; 0603	-	-
RV1	resistor; VDR; 275 V; 36 J	VDRS07H275BSE	Vishay
U1	IC; buck-boost LED driver SSL5231T	SSL5231T	NXP Semiconductors

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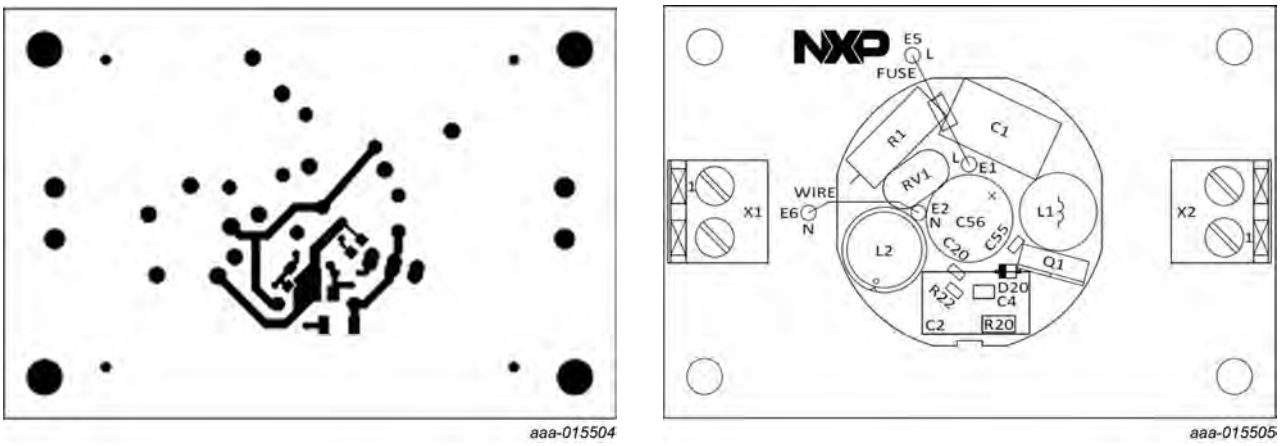
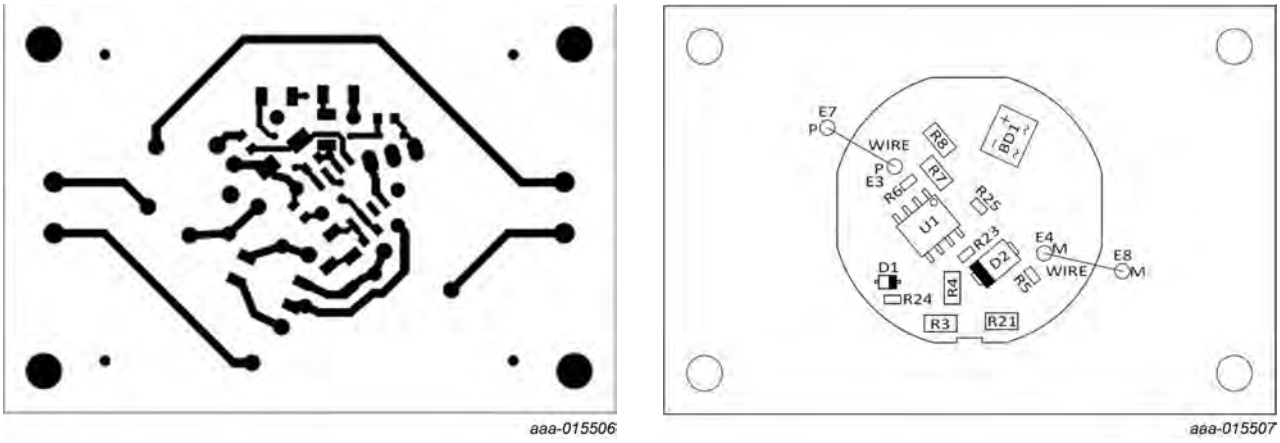
9. Board layout



a. Top view

b. Bottom view

Fig 11. SSL5231DB1242 demo board layout



a. Top view

b. Bottom view

Fig 12. SSL5231DB1242 demo board component placement

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10. Errata for improved EMI and BOM cost reduction

All measured data given in this user manual is based on the schematic (Figure 10) and the current mounted demo board SSL5231DB1242. It shows that EMC compliance, for the current setup, can only be achieved by the complete shielding of the board.

Further investigation shows that, even with a reduced BOM (Bill of Material), major behavior improvements for EMC compliance (without shielding) can be achieved. To reduce cost, the design and the board can be modified (see Figure 14). Table 3 shows the BOM of the modified schematic and improved EMI.

Modifications for the modified schematic and improved EMI:

- Remove fuse F1
- Move resistor R1 to the footprint of F1
- Short the footprint of resistor R1 using a wire
- Remove diode D1
- Remove diode D20
- Replace the current resistor R24 (220 Ω) by a 0 Ω resistor or a wire
- Remove capacitor C57

Figure 13 shows the improved conducted EMI result of the SSL5231DB1242 demo board with the modifications indicated above. No other side effects have been found.

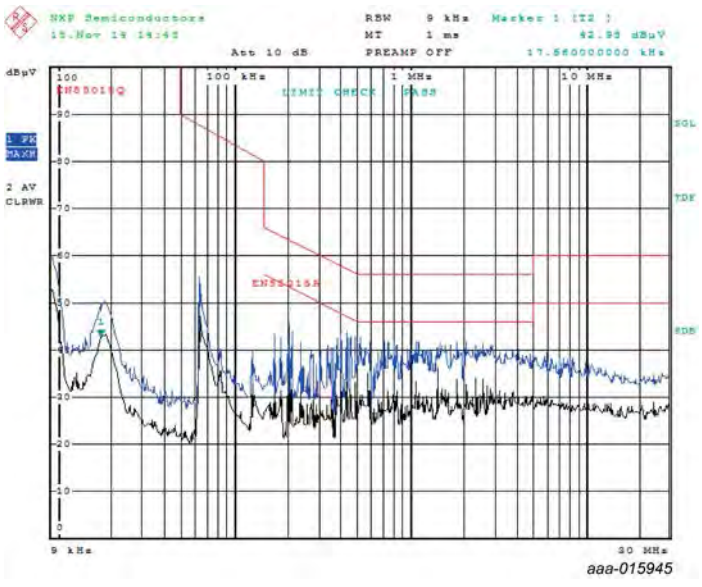

Fig 13. Improved conducted EMI

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10.1 Schematic for improved EMI and BOM cost reduction

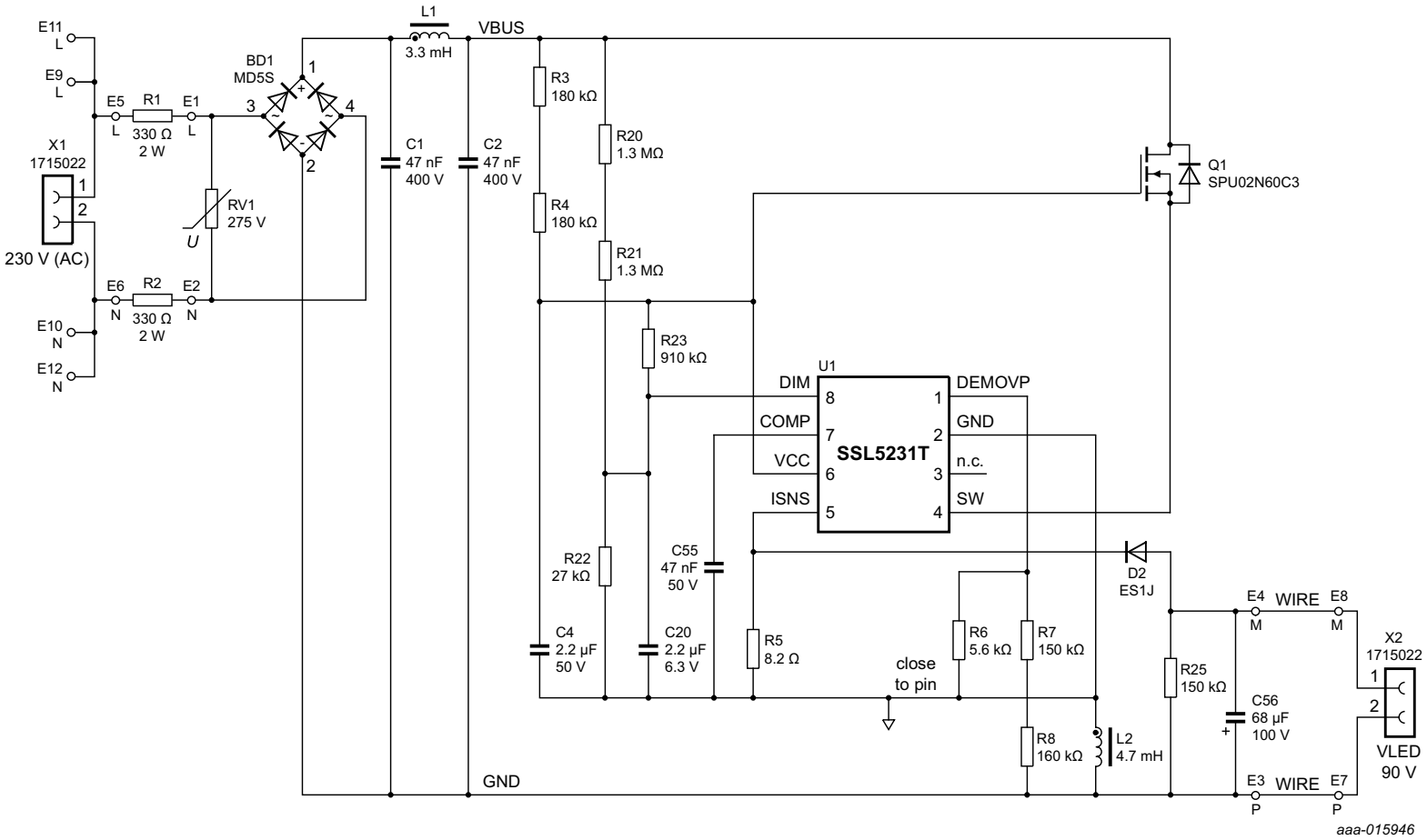

Fig 14. SSL5231DB1242 modified schematic for reduced BOM and improved EMI

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11. BOM for improved EMI and BOM cost reduction

Table 3. SSL5231DB1242 modified demo board bill of materials

Reference	Description and values	Part number	Manufacturer
BD1	bridge rectifier; 1000 V; 500 mA	MD5S	Rectron
C1; C2	capacitor; 47 nF; 5 %; 400 V; PET; THT	CL21-400V-0.047µF/K	AIDI
C4	capacitor; 2.2 µF; 10 %; 50 V; X7R; 0805	C2012X7R1H225K125AC	TDK
C20	capacitor; 2.2 µF; 10 %; 6.3 V; X7R; 0603	C1608X7R0J225K080AB	TDK
C55	capacitor; 47 nF; 10 %; 50 V; X7R; 0603	-	-
C56	capacitor; 68 µF; 20 %; 100 V; ALU; 8 mm × 20 mm	100ZLJ68M8X20	Rubycon
D2	diode; 600 V; 1 A	ES1J	Fairchild
L1	inductor; 3.3 mH; 100 mA	22R335C	Murata
L2	inductor; 4.7 mH; 10 %; 0.11 A	744731472	Würth Elektronik
Q1	MOSFET-N; 650 V; 1.8 A	SPU02N60C3	Infineon
R1; R2	resistor; 330 Ω; 5 %; 2 W; MFP2	MFP2-330RJI	Welwyn Components
R3; R4	resistor; 180 kΩ; 1 %; 250 mW; 1206	-	-
R5	resistor; 8.2 Ω; 1 %; 63 mW; 0603	-	-
R6	resistor; 5.6 kΩ; 1 %; 63 mW; 0603	-	-
R7	resistor; 150 kΩ; 1 %; 250 mW; 1206	-	-
R8	resistor; 160 kΩ; 1 %; 250 mW; 1206	-	-
R20; R21	resistor; 1.3 MΩ; 1 %; 250 mW; 1206	-	-
R22	resistor; 27 kΩ; 1 %; 63 mW; 0603	-	-
R23	resistor; 910 kΩ; 1 %; 63 mW; 0603	-	-
R25	resistor; 150 kΩ; 1 %; 63 mW; 0603	-	-
RV1	resistor; VDR; 275 V; 36 J	VDRS07H275BSE	Vishay
U1	IC; buck-boost LED driver SSL5231T	SSL5231T	NXP Semiconductors

12. Abbreviations

Table 4. Abbreviations

Acronym	Description
EMI	ElectroMagnetic Interference
LED	Light-Emitting Diode
OCP	OverCurrent Protection
OTP	OverTemperature Protection
PF	Power Factor
SSL	Solid-State Lighting

13. References

[1] SSL5231T data sheet — Compact high power factor dimmable LED driver IC

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